H2020-MSCA-ITN-ETN-2020

Project Acronym XS-Meta

MSCA Grant Agreement 956401

General description of the Project

XS-Meta is an Innovative European Training Network project with the main objective of training a new generation of researchers in concurrent material-structure design of high-technology structural systems, using functionally graded 3D-printed metamaterials.

The scientific challenge in XS-Meta is to take advantage of the metal 3D printing technology to perform a change of paradigm on how engineering structural design is performed, integrating the design of the metamaterial structure at the subscale with the engineering design of the component to develop a new generation of high-performance components. XS-Meta addresses the multiple scales of the problem, from microstructure of the material at the grain level, to the continuum-based engineering design of industrial components.

XS-Meta involves 11 partners from 7 different countries, including reference research groups in 7 leading academic institutions, one public research institute and 3 companies. XS-Meta involves different fields, from machine learning to computational and experimental materials science, manufacturing, applied mathematics, computational mechanics, and software engineering.

In the framework of this ITN, 14 early stage researchers (ESR) will be recruited with the purpose of developing research leading to a doctoral thesis. The specific profiles are listed below. The duration of each contract and of the thesis will be of 36 months. Starting date is expected between September 1st 2021 to March 1st 2022. Exact dates will be agreed between the selected candidates and the recruiting institution.

Selected candidates will be offered a fixed-term 36-month contract with the applicable benefits for the institution and country, including health coverage. Standard competitive EU-MSCA salaries are offered. The salaries are adjusted to each country living standards. Additional mobility and family allowances will be paid on the top of the salary.

To apply for these H2020-MSCA training positions, applicants must fulfil the following MSCA criteria:

- Mobility rule: Candidates must not have resided in the same country as the host (recruiting) institution for more than 12 months over the last 3 years before the starting date. This excludes holidays and (refugee status) asylum application. Candidates may be of any nationality.
- Applicant with already ESR status: Applicants must fulfill the requirements for enrolling in the PhD program of the hosting institution (or the associated academic institution in case of industry hosts). At the time of recruiting, an applicant who initiated a research career must be in the first four years of their research careers and cannot have been awarded a doctoral degree. These four years refer to the time since the researcher received the degree which would entitle him/her to embark on a doctorate. There is no age limit.

The consortium involves the following beneficiaries (recruiting institutions):

1. Universidad Politécnica de Madrid (UPM), School of Aeronautical Engineering and Space (ETSIAE), Spain.

2. Ecole Nationale d'Arts et Métiers (ENSAM), Paris (France)

3. National University of Ireland, Galway (NUIG), Ireland

4. Rheinisch-Westfälische Technische Hochschule – Aachen (RWTH), Aachen (Germany)

5. Centre National de la Recherche Scientifique, UMI with Georgia-Tech Lorraine, Metz (France).

6. Engineering System International (ESI); an engineering company of virtual prototyping software. Paris (France).

7. Oxmet-Technologies (Oxmet); a start-up company, spin-off from Oxford University, dedicated to 3D metal printing and alloy design for 3D printing, Oxford (United Kingdom)

8. Instituto Nacional de Técnica Aeroespacial Esteban Terradas (INTA), is a large research institution in the fields of defence and aerospace technologies. Torrejón-Madrid (Spain)

9. X-EV, S.R.L. (XEV) is a multinational start-up company manufacturing 3D-printed electric cars, Torino (Italy)

The consortium also involves the following partners (receiving seconded ESRs and giving training)

10. Georgia Tech, Atlanta (USA).

11. University of Florida (USA).

Application and selection process:

The candidates meeting any of the profiles and specific requirements below may apply until the positions are filled, and before July 15th for guaranteeing a full consideration. Strong communication skills in English are necessary for all the positions. Master of Science is not needed in all the positions, but in such cases additional credits on top of BS degree may be required as a requirement to enroll in the applicable PhD program.

Applications must contain:

- A motivation letter (maximum 1 page per position applied) which should state why the applicant wishes to pursue the specific research and why s/he thinks s/he is an ideal candidate for the position. If more than one position is pursued, include a motivation letter per position.
- A brief CV (typically 2 pages). If the applicant has developed previous work related to the position to which s/he is applying, an additional page may be included describing more in detail that work.
- For verifying MSCA requirements, in the first page of the CV there must be a separate section with title "MSCA requirements fulfilment", in which the candidates clearly indicate exact dates of (1) degree entitling to pursue a PhD, (2) positions and country of residence in the last 5 years.
- Up to 3 recommendation letters and/or contact e-mail addresses with a brief professional description (title, position, relationship with applicant) of the referring person.
- Copy of the title which allows to enroll in a PhD program in the country of employment (typically a Master of Science degree or Engineering degree).

The selection process will be performed in two phases. In the first phase, a pre-selection of possible candidates will be performed by the XSMETA Selection Committee. As a second step, a CV-video will be required to pass to the interview.

Applications should be submitted to the following e-mail address:

xsmetaitn@gmail.com

Include in the e-mail subject:

XS-META, ESR application for position ESR# (where # is the fellow number given below in the table)

Specific profiles and requirements of each position:

Fellow: ESR1	Host: UPM
Project Title Proposal: Mechanical and Microstructural Characterisation of 3D printed Ti-6Al-4V	
Purpose and objective: (1) To characterise the effect of 3D printing parameters, geometry and orientation of the samples on the mechanical response of Ti6Al4V, (2) to study the influence of those parameters on the microstructure and defect density and (3) to rationalise the connection between manufacturing → material → mechanical properties.	
Expected Results: Characterization of the mechanical behaviour of 3D-Ti6Al4V as a function of the 3D printing process in SLM (Selective Laser Melting) machines and posterior treatments.	
Degree requirements: MS in Mechanical Engineering, Materials Science, Physics or related field.	
Enrolment in Doctoral degree(s): Universidad Politecnica de Madrid, School of Aeronautical Engineering and Space – Materials Science and Production Department – PhD in Engineering Science. Main supervisor: Dr. Daniel Barba	

Fellow: ESR2	Host: OxMet
Project Title Proposal: Mechanical and Microstructural Characterisation of 3D printed metamaterials	
Objectives: (1) To characterise the mechanical response of different metamaterials made of 3D printed Ti6Al4V, (2) to study the influence of the type of unit cell lattice on the microstructure, geometrical accuracy and defect density of the metamaterial and (3) to rationalise the connection between metamaterial design → manufacturing →obtained material → mechanical properties.	
Expected Results: Mechanical behaviour of 3D-printed metamaterials as a function of the unit cell. Information of the geometry accuracy, microstructure of the built material and defect presence as a function of the unit cell type.	
Degree requirements: MS in Mechanical Engineering, Materials Science, Physics or related field.	
Enrolment in Doctoral degree(s): Universidad Politecnica de Madrid, School of Aeronautical Engineering and Space – Materials Science and Production Department – PhD in Engineering Science. Main supervisor: Dr. Enrique Alabort at Oxmet, and Dr. Daniel Barba at UPM	

Fellow: ESR3	Host: CNRS – UMI with Georgia-Tech at Lorraine
Project Title Proposal: Crystal plasticity modelling of 3D printed Ti6Al-4V	
Purpose and objectives: Develop crystal plasticity models and numerical techniques for 3D printed metals (as e.g. Ti-6Al-4V) which include the specific microstructure for further characterization with continuum and surrogate models. Special attention will be place regarding efficiency techniques for accelerated simulations. Propose, through predictive models, possible improvements in the 3D printing process. (1) To develop crystal plasticity framework for 3D printed Ti including the effects of the printing parameters, printing geometry and alloy; (2) To incorporate that framework in FEM software; (3) To predict the behaviour of 3D Ti-6Al-4V as a function of the printing parameters, printing geometry and orientation for ESR4.	
Expected Results: Crystal plasticity code in FEM environment, including 3DP defects; simulations of different 3D printed microstructures	
Degree requirements: MS in Mechanical Engineering, Materials Science, Physics or related field. **Additional skills:** Programming skills (Matlab, Fortran)	
Enrolment in Doctoral degree(s): Georgia Tech. Lorraine (linked third party of CNRS in the UMI)– PhD in Engineering Science. Main supervisor: Prof. Luis Barrales-Mora	

Fellow: ESR4	Host: CNRS – UMI with Georgia-Tech at Lorraine
Project Title Proposal: Continuum-type modelling of 3D printed Ti-6Al-4V metamaterial cells	
Purpose and objectives: Employing crystal plasticity simulations and data from experiments and microstructure-based simulations, through multiscale analyses, develop continuum plasticity models which incorporates the essential aspects of the microstructure of the material as a function of the powder alloy, the 3D printed processes and posterior treatments, and the 3D printing parameters. (1) To develop an efficient phenomenological continuum framework for 3D printed Ti including the effects of the printing parameters, printing geometry and alloy; (2) To incorporate that framework in FEM software; (3) To simulate efficiently the behaviour of 3D Ti-6Al-4V as a function of the printing parameters, printing geometry and orientation. (calibration from CP model in ESR3).	
Expected Results: Efficient phenomenological continuum-based framework for metamaterial cells coded in FEM software calibrated from CP model in ESR3; simulations of different metamaterial lattices obtaining the mechanical response fast as function of the unit cell	
Degree requirements: MS in Mechanical Engineering, Materials Science, Physics or related field. **Additional skills:** Programming skills (Matlab, Fortran)	

Enrolment in Doctoral degree(s): Georgia Tech. Lorraine (linked third party of CNRS in the UMI)– PhD in Engineering Science – Main supervisor: Prof. Luis Barrales-Mora

Fellow: ESR5	**Host: RWTH**
Project Title Proposal: Multiscale modelling of metamaterials	
Purpose and Objectives: (1) To develop an homogenisation RVE framework to extract the homogenised metamaterial properties applied to different discrete unit cell metamaterials; (2) To develop surrogate models equivalent to the RVE behaviour; (3) To incorporate that framework in FEM software and analyse different metamaterial families	
Expected Results: Scale up the behaviour of a discrete MM into a continuum material point. FEM subroutines including the homogenisation framework in which for a given MM cell, the code will generate a surrogate model from the equivalent continuum material point properties at the macroscale.	
Degree requirements: MS in Mechanical Engineering, Materials Science, Physics or related field. **Additional skills:** Programming skills (Matlab, Fortran, etc). Finite element analysis.	
Enrolment in Doctoral degree(s): RWTH Aachen – PhD in Engineering Science – Main Supervisor: Prof. Stephanie Reese	

Fellow: ESR6	**Host: ENSAM**
Project Title Proposal: Model order reduction algorithms for the prediction of metamaterial properties	
Purpose and objectives: In close team collaboration with ESR7 (1, ESR6) To develop model order reduction algorithms using the surrogate models for efficient inverse analyses, avoiding the curse of dimensionality and (2, ESR7) generate computational vademecums for a selected set of metamaterial families, (3, both) To develop machine learning tools to identify fictitious internal variables, correlations and functions controlling the dissipative mechanical behaviour of metamaterials	
Expected Results: Theory for parameter dimension reduction of metamaterial properties, implementation into software code and extraction of the mechanical behaviour functions of the studied metamaterial families using the code. The reduced order parametrized models are ready for being used in inverse analysis. Machine learning software tool to identify the relevant variables dominating the mechanical behaviour of the MM which will be used by ESR8. Functional functions connecting the cell topology with the instability of the metamaterial.	
Degree requirements: MS in Mechanical Engineering, Mathematics (applied), Physics or related field. **Additional skills:** Programming skills (Matlab, Fortran, C, Phython…). Finite element analysis.	
Enrolment in Doctoral degree(s): ENSAM – PhD in Engineering Science – Main Supervisor: Prof. Francisco Chinesta	

Fellow: ESR7	**Host: ENSAM**
Project Title Proposal: On the application of machine learning to the study of metamaterial mechanics	
Objectives: In close team collaboration with ESR6 (1, ERS6) To develop model order reduction algorithms using the surrogate models for efficient inverse analyses, avoiding the curse of dimensionality and (2, ESR7) generate computational vademecums for a selected set of metamaterial families, (3, both) To develop machine learning tools to identify fictitious internal variables, correlations and functions controlling the dissipative mechanical behaviour of metamaterials	
Expected Results: Theory for parameter dimension reduction of metamaterial properties, implementation into software code and extraction of the mechanical behaviour functions of the studied metamaterial families using the code. The reduced order parametrized models are ready for being used in inverse analysis. Machine learning software tool to identify the relevant variables dominating the mechanical behaviour of the MM which will be used by ESR8. Functional functions connecting the cell topology with the instability of the metamaterial.	
Degree requirements: MS in Mechanical Engineering, Mathematics (applied), Physics or related field. **Additional skills:** Programming skills (Matlab, Fortran, C, Phython…). Finite element analysis.	
Enrolment in Doctoral degree(s): ENSAM – PhD in Engineering Science – Main Supervisor: Prof. Francisco Chinesta	

Fellow: ESR8	**Host: NUIG**
Project Title Proposal: Study of metamaterial mechanical instabilities	
Purpose and objectives: The purpose of this thesis is to study the effect of the metamaterial topology on the material instabilities of the metamaterial as seen as a continuum, and to define the conditions to be met to prevent instabilities for a given set of mechanical loads. Objectives: (1) To study the effect of the cell topology on the material instabilities of the metamaterial and (2) to define cell topology boundary conditions to prevent instabilities for a given set of mechanical loads	
Expected Results: Geometrical conditions for the cell topology defining the geometrical domains for which a metamaterial is stable for a given set of mechanical loads.	

Degree requirements: BS in Mechanical Engineering, Mathematics (applied), Physics or related field. **Additional skills:** Programming skills (Matlab, Fortran, C, Phython…). Strong mathematical skills
Enrolment in Doctoral degree(s): NUIG – PhD in Applied Mathematics – Main Supervisor: Michel Destrade

Fellow: ESR9	**Host: UPM**
Project Title Proposal: Topology structural optimization algorithms applied to metamaterial components	
Purpose and Objectives: The objective is to develop component geometry optimization algorithms which also assures the connectivity of non-uniform metamaterial distribution within the component which can be used in conjunction to the optimisation tool developed by ESR10 to optimise the whole MM component in the dual scale (cell geometry + component geometry). ESR9 and ESR10 will work in close collaboration.	
Expected Results: Topological optimisation software code accounting for the metamaterial cell compatibility.	
Degree requirements: MS in Mechanical Engineering, Mathematics (applied), Physics or related field. **Additional skills:** Programming skills (Matlab, Fortran, C, Python, Julia,).	
Enrolment in Doctoral degree(s): UPM (Department of Aircrafts, School of Aeronautical Engineering and Space)—PhD in Engineering Science. Main UPM Supervisor: Prof. Francisco J. Montans. If all additional UF PhD requirements are met, there is also a possibility of obtaining a PhD by University of Florida (Dept. of Mechanical and Aerospace Engineering, Main UF Supervisor: Prof. Nam-Ho Kim).	

Fellow: ESR10	**Host: UPM**
Project Title Proposal: Non-homogeneous metamaterial optimisation for 3D printed components	
Purpose and Objectives: The purpose is to develop MM geometry optimisation tools which can be used in conjunction to the optimisation tool of ESR9 to optimise the whole metamaterial component in the dual scale (MM geometry + component geometry). ESR9 and ESR10 will work in close collaboration.	
Expected Results: Topological optimisation software code accounting for the metamaterial cell compatibility.	
Degree requirements: MS in Mechanical Engineering, Mathematics (applied), Physics or related field. **Additional skills:** Communication skills. Programming skills (Matlab, Fortran, C, Python, Julia,).	
Enrolment in Doctoral degree(s): UPM (Department of Aircrafts, School of Aeronautical Engineering and Space)—PhD in Engineering Science. Main UPM Supervisor: Prof. Francisco J. Montans. If all additional UF PhD requirements are met, there is also a possibility of obtaining a PhD by University of Florida (Dept. of Mechanical and Aerospace Engineering, Main UF Supervisor: Prof. Nam-Ho Kim).	

Fellow: ESR11	**Host: INTA**
Project Title Project: Design of lightweight 3D printed aerospace components using metamaterials	
Purpose and objectives: Select a prototype in the aerospace industry that best may benefit from the technology proposed and determine all the design requirements, characteristics, certification requirements; determine all requirements, loads, and optimization objective and to design the prototype to be manufactured using FGMMs;	
Expected Results: Design drawings of the aerospace prototype with expected performance from the software suite.	
Degree requirements: MS in Aeronautical Engineering, Mechanical Engineering, Mathematics (applied), Physics or related field. BS is admissible if the candidate fulfills the extra course credit requirements to enroll in the PhD program.	
Enrolment in Doctoral degree(s): UPM – PhD in Engineering Science – Main Supervisors at INTA: Dr. María P. Vallés, Eng. Javier SanMillán – PhD tutor at UPM: Prof. Francisco J. Montáns (Dept. of Aircrafts, School of Aeronautical Engineering and Space)	

Fellow: ESR12	**Host: X-EV**
Project Title Proposal: Design of advance 3D printed automotive components using metamaterials	
Objectives: (1) Select a prototype in the electric automotive industry that best may benefit from the technology proposed and determine all the design requirements, characteristics, certification requirements; (2) Determine all requirements, loads, and optimization objective (3) To design the prototype to be manufactured using FGMMs;	
Expected Results: Design drawings of the automotive prototype with expected performance from the software suite.	
Degree requirements: MS in Mechanical Engineering, Physics or related field.	

Enrolment in Doctoral degree(s): RWTH Aachen– PhD in Engineering Science. Main supervisor at RWTH: Prof. Stefanie Reese. Main supervisor at X-EV: Chief Veh. Engineer Simon Krechmer

Fellow: ESR13	**Host: UPM**
Project Title Proposal: Manufacturing and testing of advanced 3D printed components using metamaterials	
Purpose and objectives: (1) To develop the manufacturing route (3D printing parameters and variables, build orientation and position) for the consortium prototypes; (2) to manufacture the consortium prototypes from ESR11 and ESR12 and (3) to test the mechanical performance of the prototypes in service conditions	
Expected Results: Build files of the prototypes for the best component quality and mechanical performance of the prototypes under service conditions.	
Degree requirements: MS in Mechanical Engineering, Materials Science, Physics or related field.	
Enrolment in Doctoral degree(s): Universidad Politecnica de Madrid, School of Aeronautical Engineering and Space – Materials Science and Production Department – PhD in Engineering Science. Main supervisor: Dr. Daniel Barba	

Fellow: ESR14	**Host: ESI**
Project Title Proposal: Engineering virtual prototyping tool for metamaterial based components	
Objectives: Develop usable fully documented open-source codes of the different techniques.Transfer all the code developed into a design suite for component design using metamaterials and apply that software to the design of industrial prototypes as demonstrators. Demonstrative examples highlighting methodology	
Expected Results: Demonstrative open-source codes. Collaborate in the development of a complete industrial friendly software suite for robust and efficient design of advanced metamaterial components and proof with the design of two industrial prototypes. Demonstrative examples showing the benefits and generality of the approach	
Degree requirements: MS in Mechanical Engineering, Mathematics (applied), Physics or related field. **Additional skills:** Ability for teamwork and interest in developing simulation software. Programming skills (Matlab, Fortran, C, Phython…). Finite element analysis.	
Enrolment in Doctoral degree(s): ENSAM – PhD in Engineering Science. Main Supervisor: Prof. Francisco Chinesta.	